Abstract

Cardiovascular diseases (CVDs) are the leading cause of death globally. Among CVDs, cardiac arrhythmias are the major contributors to CVD-related mortality, highlighting the importance of accurate diagnosis and monitoring of these conditions. The detection and classification of cardiac arrhythmias often rely on electrocardiogram (ECG) analysis, which is commonly performed by trained cardiologists. However, in clinical settings such as the intensive care unit (ICU), time is of the essence, and it can be challenging for a cardiologist to detect and diagnose cardiac arrhythmias quickly. Therefore, the development of computer-aided diagnostic (CAD) systems are necessary in clinical settings to automate ECG analysis and assist cardiologists. However, in a clinical environment during data acquisition, the ECG signals are often corrupted by various types of noise, hindering their accurate interpretation. Consequently, our research focuses on two primary challenges in ECG analysis: denoising and arrhythmia classification. Effective denoising techniques are essential for improving the accuracy of ECG diagnosis, while accurate arrhythmia classification algorithms aid in early detection and diagnosis of cardiovascular diseases.

This thesis presents three novel approaches to address the challenges of ECG denoising and arrhythmia classification. Firstly, a hybrid method for the removal of power line interference (PLI) and baseline wander (BW) in ECG signals is proposed, based on empirical mode decomposition (EMD) and empirical wavelet transform (EWT). Secondly, a patient-specific ECG heartbeat classification framework is introduced, utilizing long short-term memory (LSTM)-based recurrent neural networks (RNNs). Lastly, an inter-patient ECG heartbeat classification method is presented, which integrates convolutional neural network (CNN) and LSTM networks. The proposed frameworks are validated through experiments conducted on real ECG signals from the MIT-BIH arrhythmia database. The results demonstrate that the proposed methods outperform existing state-of-the-art techniques, showcasing their effectiveness in ECG denoising and arrhythmia classification tasks. These advancements contribute to improving the accuracy of ECG diagnosis and facilitating early detection and diagnosis of cardiovascular diseases.

Keywords: Cardiovascular disease, electrocardiogram, empirical mode decomposition, empirical wavelet transform, recurrent neural network, long short-term memory, feature extraction, convolutional neural network.